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Application Date: 21st Apr., 1937. No. 1555/37.

Applicant	KODAK (AUSTRALASIA) PROPRIETARY LIMITED.
Assignor	EASTMAN KODAK COMPANY, of New York, U.S.A.
Actual Inventors	LEOPOLD DAMROSCH MANNES and LEOPOLD GODOWSKY, Jnr., of New York, U.S.A.
Application and Complete Specification ..	Accepted, 25th January, 1938.
Acceptance Advertised (*Sec.* 50)	10th February, 1938.

Classes 52.9; 52.3; 01.7.

Drawing attached.

COMPLETE SPECIFICATION.

"Sound track for multi-layer film."

We, KODAK (AUSTRALASIA) PROPRIETARY LIMITED, a Company registered under the laws of the State of Victoria, and having its registered office at Southampton Crescent, Abbotsford, in the State of Victoria, Commonwealth of Australia, Manufacturers, hereby declare this invention and the manner in which it is to be performed to be fully described and ascertained in and by the following statement:—

This invention relates to sound tracks in photographic film and particularly to a method for producing a sound track in multi-layer film in which colored images are produced.

Our prior Australian Patent Specification No. 25,194/35, describes a method for producing natural colored images in photographic film having three differentially sensitized layers on one side of a support. According to the method described in our prior application the film is exposed to the object to be recorded and is then developed in an ordinary developer. The silver image is then removed by a suitable solvent. If a reversed image is to be formed or if a

negative is desired the film is fixed to remove undeveloped silver halide and the remaining silver bleached to a developable salt. In the former case there remains a developable salt of a reversed or positive image and in the latter case a developable salt of a negative image. The developable images formed in this way are subjected to a color-forming development in which color images are formed in each of the layers by coupling of a suitable compound with the oxidation product of the developer. The upper layers of the film are then subjected to a controlled bleaching operation which destroys the color images in the upper layers and again forms a developable salt in these layers. The upper layers are then again developed to form colored images and the upper or outermost layer again bleached and recolored to form a third colored image.

In the preferred form of the process described in our prior application the lowermost layer of the final film carries a minus red image, the middle layer carries a minus green image and the upper or outer layer carries a minus blue image. Of these three

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images the minus red image is the only one of the three which is at all suitable for the formation of a sound track, on account of its high degree of absorption of red light. This minus red image is on the bottom or inner emulsion layer and if the sound track is recorded or printed from the outer surface the passage of the light through the upper two emulsion layers decreases the resolving power of the lower layer image considerably below the required limit. The sound image might be recorded through the film support but this would require local or total removal of the backing with consequent danger of halation and the added problem of noise due to the recording of scratches on the film base. In our prior application we also proposed recording the sound image in all three emulsion layers. Here too, however, there is a lowering of the resolving power of the image.

It is, therefore, an object of the present invention to provide an improved sound track in photographic film having three superposed differentially sensitized layers used for color photography. A further object is to provide a sound track which will not be affected by subsequent bleaching and color development steps of the multi-layer film. A still further object is to provide a sound track in multi-layer film having a high resolving power.

As the upper emulsion layer of the multi-layer film described in our prior Australian Patent Specification No. 25,194/35 has a high resolving power, which is further increased, for blue light, by the presence of a yellow filter dye, this layer is well suited to the requirements of a sound track. However, the minus blue dye image remaining in this layer after development is virtually useless as it is nearly transparent to the photo-electric cell used in sound reproducing. It is, therefore, proposed to utilize the silver image in the top layer before it is finally removed by converting it to silver sulfide in the sound track area.

In the accompanying drawing:—

Fig. 1 is a diagrammatic view of the apparatus used in the formation of a silver sulphide sound track;

Fig. 2 is a flow sheet showing the steps in the formation of the sound track; and

Fig. 3 is a plan view showing the method of applying treating solutions to the sound track area of the film.

For a negative-positive process the sound track record can be confined to the top layer by recording or printing through a blue filter. For a reversal process the sound track may be confined to the surface layer by one of two methods. The first method is to record through a blue filter and fully flash the sound track through a yellow filter, and thus clearing out the lower two layers, which are sensitive to red and green light, by reversal. This leaves the image in the upper layer only. The second method which is particularly applicable to direct camera recording is to use a lamp operated at sufficiently low color temperature to give a predominantly yellow-orange light. An exposure which is sufficient to produce a correct sound image by blue light in the upper layer will then automatically overexpose the records in the lower two layers to give a relatively low density in these layers after reversal.

A conversion of the sound track image to silver sulfide may be effected at any stage in the process at which there is still silver in the image. In the case of the multi-layer film described in our prior application, No. 25,194, the most suitable point in the processing is after the blue development and treatment in hypo at which point the film is dried. At this point the film contains images of metallic silver and blue-green dye in each of the layers as well as in the upper layer of the sound track area. The sound track may be bleached to halide or other salts of silver, such as silver ferrocyanide, by means of an applicator rollers or other device affecting the sound track portion only. The sound track image is then converted to silver sulfide which is not affected by succeeding steps in the color development process. It is immaterial whether or not the blue-green dye image remains with the sound track silver sulfide, as subsequent bleach baths will remove it.

The bleached silver halide sound track image may be converted to silver sulfide in a number of ways. The film may be washed and immersed in developable sulfide solution which will cause conversion of the sound track portion only to silver sulfide. The film may also be treated with ammonia and hydrogen sulfide vapor to convert the silver chloride to silver sulfide.

A further method of local sulfiding of the sound track area is to apply a sulfide solution by means of an applicator roller or other suitable device to the sound track portion of the film after it emerges, thoroughly squeegeed, from either of the two differential bleaches used for halogenizing the upper or upper two layers in the differential process described in our prior Australian Application No. 25,194.

In Fig. 1 of the accompanying drawing we have shown in diagrammatic form apparatus used in the preferred method of forming the silver sulfide sound track, according to our invention. As shown therein the film **10** which contains images of metallic silver and blue-green dye in the layers of the picture area and the upper layer of the sound track area is coated with water from the applicator portion **11** of the hopper **12**. The water may contain a small amount of a suitable wetting agent, such as saponin, to overcome the surface repellancy of the blue-green film and a small amount of a moisture-retaining agent, such as glycol or glycerin, in order to prevent drying out of the moistened strips at the edges during the subsequent gas-treating process.

After being moistened on the sound track portion the film is passed through a slit into chamber **14** and over a roller into chamber **15** in which it is treated with chlorine or bromine gas which enters the chamber by a pipe **16**.

The film then passes out of chamber **15** and over another roller into a drying chamber **13** in which it is washed free of bleaching gas by a current of air which enters the chamber **13** by means of conduit **17** and leaves by means of conduit **18**. The humidity of the current of air passed through the chamber **13** must be carefully controlled to prevent drying of the moistened film. The current of air is for the purpose only of removing the chlorine or bromine bleaching gas.

The film is then passed over a third roller into the chamber **19** and thence into the chamber **20** where it is treated with ammonium sulfide vapor or hydrogen sulfide gas entering through pipe **21**. After this treatment the film passes over a fourth roller in chamber **19** and thence out of the chamber. The sulfiding agent used in chamber **20** may also be supplied by bubbling air of ammonium sulfide at the bottom of the vessel or by trickling ammonium sulfide solution down the side of the vessel.

The toning vessels **15** and **20** are connected to their respective chambers **14** and **19** and each of these chambers is connected to a line **22** on which a slight suction is maintained. Since both of the gases used in the toning are heavier than air, they are retained in the toning vessels by gravity. Any air leaking into the suction boxes **14** and **19** is immediately swept up by ducts **22**, the toning gases being lost only to a small degree by being carried away as surface layers on the film.

It is important to control the humidity during the entire gas toning operation. If the humidity is too low the moistened strip may become edge-dried and if the humidity is too high, the picture area may be visibly affected and objectionable surface deposits may be formed. The gas toning operation should preferably be carried out at a temperature of 60°F. or lower. The humidity should be between about 40% and about 60%. This humidity must also be maintained sufficiently high in the drying chamber **13** to prevent drying during the removal of the halogen gas. This chamber is kept at a temperature of 50 to 60°F., and a relative humidity of between 40% and 60%.

It is also important to remove any traces of free sulfide from the toned film before the subsequent bleaching and color-forming development steps of our process. The purpose of the bleaching step following the recording of the sound according to our preferred method is to transform the silver images in certain layers of the picture area to silver halide which is developable. The presence of any free sulfide in the bleach bath causes the silver image being bleached to be transformed to opaque silver instead of to silver halide. Such contamination of the picture with silver sulfide would mean sacrificing picture quality in order to obtain good sound quality.

The free sulfide is removed from the film by washing the film in chamber **23** by a spray of water from pipe **24**. The water jets are preferably directed obliquely across the film from the picture area toward the sound track. This washing is followed by squeegeeing the film as shown at **25** after which it passes through a drying chamber

26, in which it is thoroughly dried, preferably by the use of warm air. The film may also be treated with chlorine or bromine gas or with a solution of chlorine or bromine, to oxidize any unused sulfide on the film.

A second method for sulfiding the sound track employs the application of a liquid bath containing a soluble sulfide. The bath employs a quinone bleaching agent and hydrochloric acid and converts the sound track to silver sulfide in a single operation. The liquid sulfiding bath may be applied by applicator 11 in the same manner as the water of the gas toning method. A suitable liquid sulfide bath may have the following composition:

Glycerin	..	100 grams
Hydrochloric acid	..	20 grams
Quinone	..	5 grams
Sodium sulfide	..	35 grams
Water	..	1 liter

The sodium sulfide used in this formula may vary from a few tenths of 1% to about 3% or more of the amount of solution by weight.

In this method of sulfiding an after-treatment is also necessary to oxidize or remove unused sulfide. This may be done by treating with chlorine or bromine gas as described above, or by strip application of a chlorine or bromine solution.

In Fig. 2 of the drawing we have shown the series of steps of forming the silver sulfide sound track as represented by successive sectional views of the film. As shown therein 27 represents a multi-layer film having a transparent base. The sound track portion of the film is exposed through a mask 28 which prevents exposure of the picture area, the sound being recorded by a suitable recording device, the objective of which is represented at 29. The sound track may be recorded before or after exposure of the picture area of the film.

After development the sound track area of the film appears as an image 30 in the upper layer of the film and a fogged image 31 in the two lower layers of the film. It is assumed that the sound track is formed in a film being processed according to the reversal method and that the lower two layers have been fogged by one of the methods described above.

After bleaching, re-exposure and development of the film in the usual way as performed in the reversal method, the sound track appears as complementary image 32, the fogged image in the lower layers being removed by this treatment. After sulfiding by one of the methods described above, the sound track appears as silver sulfide as shown at 33. The film is then ready for the remaining processing steps to form colored images in the picture area.

Fig. 3 shows in enlarged form the applicator roller 11 used to apply the water or sulfiding solution to the film 10. The liquid applied to the sound track in this way is represented at 34.

The sound track formed of silver sulfide according to our method has a number of advantages. It is easy to form by a sulfiding method such as those described above, it is opaque to the photo-electric cell used in sound reproducing, and it is not affected by successive processing steps of bleaching and color developments according to our preferred method of forming colored images. We are aware that photographic sound records of silver sulfide have been described hitherto, for example, by J. G. Capstaff in U.S. Patent No. 1,973,463, granted September 11, 1934. Disclosures of this type do not, however, suggest a solution of the present problem, in which it is desired to form a sound track in a film which may contain latent picture images in adjacent layers and which will not require some special treatment, such as varnishing, to prevent its destruction by subsequent steps of our process employing bleach baths and color-forming developing operations.

Our method is susceptible of numerous modifications and is to be limited only by the scope of the appended claims.

Having now fully described and ascertained our said invention and the manner in which it is to be performed, we declare that what we claim is:—

1. The method of forming sound and natural colour picture images in a film having a plurality of differentially sensitized layers on one side of a transparent support, which comprises forming images of metallic silver and dye in both sound and picture areas, converting only the silver sound image to silver sulfide, and processing

the image in the picture area to a natural-color dye image without affecting the sound image.

2. The method of forming sound and natural colour picture images in a film having a plurality of differentially sensitized layers on one side of a transparent support, which comprises forming images of metallic silver in both sound and picture areas, converting only the silver sound image to silver sulfide, bleaching the film in a bath which affects metallic silver but not silver sulfide to convert certain of the picture images to developable salts, and coloring these picture images to form a natural color image.

3. The method of forming sound and natural color picture images in a film having a plurality of differentially sensitized layers on one side of a transparent support, which comprises forming images of metallic silver in both sound and picture areas, the image in the sound area being only in the layer farthest from the support, converting only the sound image to silver sulfide, bleaching the film in a bath which affects metallic silver but not silver sulfide to convert certain of the picture images to developable salts, and coloring these images by a color-forming process to form a natural-color image.

4. The method of forming sound and natural-color picture images in a film having a plurality of differentially sensitized layers on one side of a transparent support, which comprises forming images of metallic silver in both sound and picture areas, the sound image being formed only in an upper layer of the film and the lower layers being fogged, subjecting the film to a reversal development to produce complementary silver images in the picture area and the sound area of the upper layer, and to clear the sound area of the lower layers, converting only the sound image to silver sulfide, treating the film in a bath which bleaches metallic silver but not silver sulfide to convert certain of the picture images to developable salts, and coloring these images by a color-forming process to form a natural-color image.

5. In the method of forming sound and natural-color picture images in a multilayer film, the steps comprising forming the sound image of silver sulfide, then forming the natural-color picture images by successive color development steps in which the images are formed by coupling a color-forming compound with the oxidation product of the developer.

Dated this 20th day of April, A.D. 1937.

CECIL W. LE PLASTRIER,

Phillips, Ormonde, Le Plastrier & Kelson,

Agents for Applicant.

Witness—L. Spinks.

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Ag2S sound Track

FIG. 1.

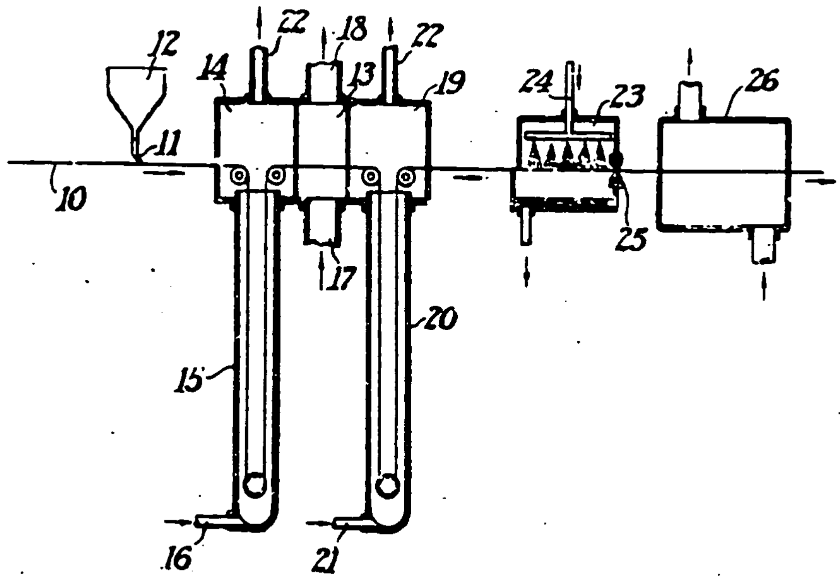

FIG. 2.

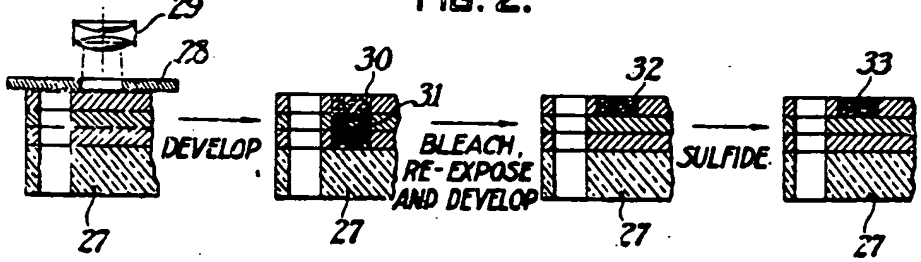

FIG. 3.